

## CHAPTER 7. ENERGY USE CHARACTERIZATION

### TABLE OF CONTENTS

7.1	INTRODUCTION .....	7-1
7.2	APPROACH TO ENERGY USE ANALYSIS .....	7-1
7.3	ENERGY USE FOR WALK-IN COOLERS AND FREEZERS .....	7-1
7.3.1	Sizes and Product Classes Analyzed for Energy Use .....	7-2
7.3.2	Direct Energy Consumption .....	7-3
7.3.3	Product Load .....	7-4
7.3.4	Envelope Load .....	7-4
7.3.5	Assumptions for Computing the Product Cooling Load.....	7-5
7.3.6	Duty Cycle .....	7-6
7.3.7	Matching of the Refrigeration Capacity .....	7-7
7.3.8	Mismatch Factor .....	7-7
7.3.9	Normalized Energy Consumption (NEC) for the Refrigeration System .....	7-9
7.4	ENERGY ANALYSIS RESULTS .....	7-9
7.5	State-by-State Annual Energy Consumption .....	7-10

### LIST OF TABLES

Table 7.3.1	WICF Envelope Classes and Sizes for Energy Use Analysis.....	7-2
Table 7.3.1	Equipment Classes for Refrigeration Equipment .....	7-3
Table 7.3.2	Combination of WICF Envelopes and Refrigeration Systems Analyzed.....	7-3
Table 7.3.3	Daily Direct Electrical Energy Consumption of the Envelopes (kWh/Day) .....	7-4
Table 7.3.4	Envelope Refrigeration Loads (kBtu/Day) .....	7-5
Table 7.3.5	Assumptions for Estimation of Nominal Product Load.....	7-5
Table 7.3.6	Capacities and Oversize Factors for the Refrigeration Systems .....	7-8
Table 7.4.1	Annual Energy Consumption Estimates for a Medium Non-Display Cooler Matched with a Dedicated Medium-Temperature Outdoor System (kWh/ year).	7-10
Table 7.5.1	State-wise Annual Energy Consumption Estimates for a Baseline Small Non- Display Cooler Envelope matched with Outdoor medium Temperature System (kWh/year) .....	7-11

### LIST OF FIGURES

Figure 7.3.1	Oversize Factor vs. Required Capacity Plot.....	7-9
--------------	---	-----

## **CHAPTER 7. ENERGY USE CHARACTERIZATION**

### **7.1 INTRODUCTION**

This chapter presents the U.S. Department of Energy's (DOE's) analysis of annual energy usage of complete walk-in cooler and freezer (WICF) systems at various efficiency levels of the main subsystems, *i.e.*, the envelope and the refrigeration system. These estimated values of annual energy usage (kWh/yr) are key inputs to the determination of life-cycle cost (LCC) and payback period (PBP) analyses (chapter 8 of the preliminary technical support document [TSD]) as well as national impacts analyses (chapter 10 of the preliminary TSD).

### **7.2 APPROACH TO ENERGY USE ANALYSIS**

The TSD chapter on engineering analysis (chapter 5) provides estimates of nominal energy consumption for the two principal components of the WICFs; *i.e.*, the envelope and the refrigeration system at baseline and at several higher efficiency levels ideally matched with a nominally sized counterpart system. There are multiple independent design options with varying cost incidences available for each of these subsystems for achieving aggregate energy savings for the complete system. Thus, many design options are analyzed for a complete WICF system, being the multiplication product of the individual separate design options for the envelope and the refrigeration system. The annual energy consumption for any given system in the set of complete systems configured with the envelope at a specific efficiency level, and a matched refrigeration system, also at a specific efficiency level, is ascertained using a set of assumptions for product loading, duty cycle, and other associated conditions. WICF systems are often custom built with varying envelope dimensions, they cater to different refrigeration loads, and they are configured with different classes of refrigeration systems. Therefore, DOE considered three typical sizes in each of the product classes of envelope as analysis points and estimated the energy consumption for these sizes. Four envelope classes and six refrigeration system classes were analyzed at multiple analysis points in the engineering analysis (chapter 5 of the preliminary TSD). Energy usage for the combined walk-in system was estimated by matching each analysis point of all the envelope classes to an appropriate refrigeration system class sized to one of the possible analysis points.

### **7.3 ENERGY USE FOR WALK-IN COOLERS AND FREEZERS**

The aggregate energy consumption of a complete walk-in system comprises the energy consumption due to three distinct subsets of components:

1. Energy consumed directly by envelope components, *i.e.*, lights, anti-sweat heaters, powered secondary devices for infiltration reduction, etc. (direct energy consumption)
2. Energy consumed by components of the refrigeration systems inside the envelope, *i.e.*, evaporator fans, defrost energy, etc., and
3. Energy consumed by the refrigeration system components outside the envelope, *i.e.*, the compressor motor and the condenser fan motor.

Refrigeration or envelope-related components, located inside the cooled space, also generate waste heat and add to the refrigeration load of the envelope. The additional heat load must also be removed by the refrigeration equipment, thereby adding to the refrigeration system electricity consumption.

### 7.3.1 Sizes and Product Classes Analyzed for Energy Use

The sizes and the product classes for the walk-in envelopes for energy use analysis are identical to the four primary walk-in envelope classes identified for the engineering analysis. These are (1) non-display coolers; (2) non-display freezers; (3) display coolers, and (4) display freezers. Three typical sizes were chosen from each envelope equipment class for energy-use analysis as was done for the engineering analysis. Table 7.3.1 gives details of the dimensions of the envelopes, the respective product classes, and the product class and size code. In later discussions, the envelopes are identified by the composite product code that comprises the product class code and the size code, *e.g.*, the product code display cooler-small (DCS) refers to the small-sized display cooler.

**Table 7.3.1 WICF Envelope Classes and Sizes for Energy Use Analysis**

	Dimensions [length × width × height, ft]			
Class	Small	Medium	Large	Class Code
Non-Display Cooler	10' × 8' × 7.6'	12' × 20' × 9.5'	25' × 30' × 12'	SC
Non-Display Freezer	8' × 6' × 7.6'	9' × 20' × 9.5'	25' × 20' × 12'	SF
Display Cooler	6' × 6' × 6.6'	10.2' × 7' × 7.6'	80' × 15' × 7.6'	DC
Display Freezer	6' × 6' × 6.6'	10.2' × 7' × 7.6'	80' × 15' × 7.6'	DF
Size Code	S	M	L	

For the refrigeration systems, DOE analyzed the six primary walk-in refrigeration system classes taken up from the engineering analysis. These include dedicated indoor systems, dedicated outdoor systems, and unit coolers connected to Multiplex Systems for both medium and low temperature applications. DOE chose two representative sizes (small and large) from each of the six refrigeration system product classes for energy-use analysis. Each envelope product class could be matched with one of the three medium or low-temperature refrigeration equipment classes. The size of the refrigeration system matched with the WICF envelope was based on the nominal capacity of the specific size of the refrigeration system and the cooling load of the envelope. Table 7.3.3 gives the details of the matched refrigeration systems for each WICF analyzed. The class codes for the refrigeration systems are defined in

Table 7.3.2, and the size descriptions are abbreviated; *i.e.*, Lg. and Sm. stand for the large and small sized system, respectively.

**Table 7.3.2 Equipment Classes for Refrigeration Equipment**

Condensing Type*	Operating Temperature	Condenser Location	Class
Multiplex	Medium	-	MC.M
	Low	-	MC.L
Dedicated	Medium	Indoor	DC.M.I
	Low		DC.L.I
	Medium	Outdoor	DC.M.O
	Low		DC.L.O
*Note: For each of the six equipment classes, two analysis points will be used, corresponding to small and large representative units.			

**Table 7.3.3 Combination of WICF Envelopes and Refrigeration Systems Analyzed**

Class/ Size code	SCS	SCM	SCL	DCS	DCM	DCL	SFS	SFM	SFL	DFS	DFM	DFL
DC.M.I-Sm	√											
DC.M.I-Lg		√	√	√	√	√						
DC.M.O-Sm	√											
DC.M.O-Lg		√	√	√	√	√						
MC.M-Sm	√											
MC.M-Lg		√	√	√	√	√						
DC.L.I-Sm							√					
DC.L.I-Lg								√	√	√	√	√
DC.L.O-Sm							√					
DC.L.O-Lg								√	√	√	√	√
MC.L-Sm							√					
MC.L-Lg								√	√	√	√	√

### 7.3.2 Direct Energy Consumption

The methodology for estimating the direct energy consumption under different engineering options for the envelope has been explained in detail in chapter 5 of the preliminary TSD (sections 5.5). Table 7.3.4 gives details of the daily direct electrical energy consumption of the envelope.

**Table 7.3.4 Daily Direct Electrical Energy Consumption of the Envelopes (kWh/Day)**

Class/ Size Code	SCS	SCM	SCL	DCS	DCM	DCL	SFS	SFM	SFL	DFS	DFM	DFL
Efficiency Levels												
0	0.36	0.36	1.08	12.41	32.17	100.90	4.75	5.30	10.42	20.10	43.95	123.41
1	0.36	0.36	1.08	7.28	18.48	64.82	4.75	5.30	10.42	12.49	23.68	87.34
2	0.17	0.17	0.50	3.26	11.64	64.82	4.56	5.11	10.42	12.49	23.68	87.34
3	0.17	0.17	0.50	3.26	11.64	38.68	4.56	5.11	9.84	8.47	17.53	87.34
4	0.17	0.17	0.50	1.86	6.61	15.45	4.56	5.11	9.84	8.47	13.01	61.19
5	0.17	0.17	0.50	1.55	2.90	10.17	4.56	5.11	9.84	6.25	7.10	24.23
6	0.17	0.17	0.50	1.55	2.05	10.17	4.56	5.11	9.84	5.94	7.10	18.95
7	0.17	0.17	0.50	0.89	2.05	10.17	4.56	5.11	9.84	5.94	6.25	18.95
8	0.17	0.17	0.37	0.89	2.05	10.17	4.56	5.11	10.52	5.28	6.25	18.95
9	0.17	0.17	0.37	0.89	2.05	10.17	4.56	5.56	10.52	5.28	6.25	18.95
10	0.17	0.17	0.37	0.89	2.05	10.17	4.79	5.56	10.52	5.28	6.25	18.95
11	0.17	0.17	0.37	0.89	2.05	10.17	4.79	5.56	10.38	5.28	6.25	18.95
12	0.17	0.17	0.37	0.89	2.05	10.17	4.79	5.56	10.38	5.28	6.25	18.95
13	0.17	0.17	0.37	0.89	2.05	10.17	4.79	5.56	10.38	5.28	6.25	18.95
14	0.17	0.17	0.37	0.89	2.05	10.17	4.79	5.56	10.38	5.28	6.25	18.95
15	0.17	0.17	0.37	0.89	2.05	10.17	4.82	5.60	10.38	5.75	7.12	18.95

### 7.3.3 Product Load

The aggregate refrigeration load in the envelope comprises the product load and the non-product load. The product heat load is the load associated with WICF's essential function of maintaining the optimal storage conditions defined by the specified temperature and humidity ranges for the products inside, *i.e.*, the load directly related to the products stored in the WICF envelope. This generally includes the product "pull-down" load, which is the load associated with reducing the temperature of delivered products down to the desired storage temperature of the walk-in. This load varies with both the delivered product temperature and specific heat. The product load may occasionally include latent loads associated with products required to be frozen and also loads associated with the respiration of fresh fruits and vegetables.

### 7.3.4 Envelope Load

The envelope (non-product) refrigeration load is composed of the following: (1) the heat transmitted through the envelope via conduction; (2) the air infiltration through the panel and door joints and also through open doors; and (3) the heat load due to the operation of the electrical components inside the envelope.

The methodology for computing the heat loads following the DOE test procedure is explained in detail in preliminary TSD chapter 5 for the Engineering Analysis. Non-product refrigeration load is computed in detail for all the design options of the four classes of envelopes in three different typical sizes. The detailed calculations for these are shown in the spreadsheets for engineering analysis for the envelope. The envelope heat loads in kBtu/day are shown in Table 7.3.5.

**Table 7.3.5 Envelope Refrigeration Loads (kBtu/Day)**

Class/ Size Code	SCS	SCM	SCL	DCS	DCM	DCL	SFS	SFM	SFL	DFS	DFM	DFL
Efficiency levels												
0	60	138	279	283	684	3,851	132	315	596	383	823	4,375
1	33	71	164	265	638	3,727	53	120	261	357	754	4,252
2	32	71	162	252	614	3,330	52	120	259	218	515	3,094
3	22	70	161	204	532	3,241	50	119	257	204	494	3,091
4	20	52	153	147	515	2,292	48	114	246	203	478	3,002
5	20	49	145	87	363	1,293	48	107	232	180	416	2,616
6	19	46	115	80	203	1,291	47	105	224	118	415	1,587
7	18	44	111	78	193	1,285	44	97	207	117	250	1,574
8	16	40	110	77	193	1,235	44	95	177	114	250	1,557
9	15	37	99	77	192	896	42	77	172	114	248	1,539
10	12	29	91	56	192	888	35	72	160	114	247	1,519
11	10	24	90	56	137	881	31	62	159	112	245	1,153
12	9	21	79	56	137	871	29	56	150	90	186	1,141
13	8	20	73	55	136	864	28	52	150	90	186	1,127
14	8	20	60	55	135	864	27	50	128	89	184	1,125
15	8	20	53	54	134	856	26	50	117	76	163	1,110

### 7.3.5 Assumptions for Computing the Product Cooling Load

For the energy-use analysis of the WICF systems, the aggregate refrigeration load for each of the twelve WICF envelope sizes is obtained by adding nominal product loads to the envelope non-product heat load. The assumptions made for calculating the product load are described below. The key parameters that determine the product load are the product pull-down temperature, the product-specific heats, and the daily loading ratio of the products in relation to the interior refrigerated space of the WICF. Table 7.3.6 gives details of the parameters assumed for different product classes for the typical sizes considered for the analysis.

**Table 7.3.6 Assumptions for Estimation of Nominal Product Load**

Parameter	Units	SC S	SC M	SC L	DCS	DC M	DCL	SF S	SFM	SF L	DFS	DFM	DF L
Product Pull down TD	(°F)	10	10	10	10	10	10	10	10	10	10	10	10
Product specific heat	Btu/lb / °F	0.9	0.9	0.9	0.9	0.9	0.9	0.45	0.45	0.45	0.45	0.45	0.45
Daily Loading Ratio	Lbs/cft	4	2	2	4	2	2	1	0.5	0.5	1	0.5	0.5

From the physical dimensions of the envelope, the gross inside volume was computed. This was multiplied by the daily loading ratio (lbs/cft) to obtain the lbs of product that is loaded in the envelope on daily basis and generated the daily pull-down load for the envelope. The daily loading ratio is different from the actual average loading ratio obtained by dividing the maximum weight of the products stored in the WICF by the volume of the refrigerated space. The daily loading ratio is lower

than the actual average loading ratio to reflect the quantity of products delivered on daily basis. The assumed daily loading ratios were higher for the coolers than for the freezers and higher for the smallest sizes of the envelopes than for the intermediate and higher sizes. The product-specific heats were assumed at 0.45 Btu/lb/ °F for the frozen products and 0.9 Btu/lb/ °F for all products stored in the WICF coolers. The pull-down temperatures were taken at 10 °F for both the coolers and freezers to represent an average loading condition. DOE believes that these conditions represent the typical conditions found in the industry, and based on these assumptions, a reasonable nominal product load could be estimated that could be used for further analysis.

### 7.3.6 Duty Cycle

The nominal product cooling load was added to the non-product cooling load for obtaining the aggregate daily cooling load for the envelope. The aggregate refrigeration load is required to be removed from the envelope interior for maintaining the specified temperature condition inside the envelope. The refrigeration system to be matched with any given envelope is required to have adequate capacity to meet the “high load” condition of the envelope and to also have enough reserve capacity for meeting unexpectedly high product-load situations or unusually hot outside weather conditions. DOE defined the high-load factor as the ratio of the high hourly load to the average refrigeration load of the envelope over a 24-hour period. DOE modeled the “high load” factor to conform to the assumptions made in AHRI standard 1250 to calculate the envelope load (section 6). In AHRI Standard 1250, it was assumed that for a walk-in system with an indoor condensing unit, the high envelope load (BLH) is 70 percent of the capacity of the refrigeration system ( $q_{ss}$ ) at the specified temperature of 90 °F, and the low envelope load (BLL) is 10 percent of the refrigeration system capacity at ( $q_{ss}$ ). It is further assumed in AHRI 1250 (section 6) that the high-load period (BLH) occurs for 8 hours per day. The average envelope load (BLA) for the above situation could be derived as follows:

$$BLA = (8 BLH + 16 BLL) / 24 \quad \text{Eq. 7.1}$$

$$BLH = 0.7 q_{ss} \quad \text{Eq. 7.2}$$

$$BLL = 0.1 q_{ss} \quad \text{Eq. 7.3}$$

Using the above equations, DOE obtained that the high load factor for the walk-in coolers at 2.33. An identical relationship is obtained for the coolers with external condensers. For the freezers with the internally located condensers, the corresponding relationships from AHRI 1250 are:

$$BLH = 0.8 q_{ss} \quad \text{Eq. 7.4}$$

$$BLL = 0.4 q_{ss} \quad \text{Eq. 7.5}$$

The average envelope load (BLA) for freezers is derived with duty cycle condition identical for coolers (8 hours of high load operation, and 16 hours of low load operation). DOE used the above relationships to obtain the high load factor of 1.5 for the walk-in freezers.

### 7.3.7 Matching of the Refrigeration Capacity

For obtaining a matched refrigeration systems for the given envelope, DOE derived the hourly peak refrigeration load (kBtu/hr) for the envelope, and then used the corresponding equations in AHRI 1250 to arrive at the matched capacity. These equations are as follows

For WICF cooler systems:

$$BLH = 0.7 q_{ss} \quad \text{Eq. 7.6}$$

For WICF freezer systems:

$$BLH = 0.8 q_{ss} \quad \text{Eq. 7.7}$$

The refrigeration system capacity in the above equations is the measured net capacity of the refrigeration system measured with testing methodology and rating conditions described in AHRI 1250. For the dedicated systems,  $q_{ss}$  is the measured value at the outside ambient temperatures of 95 °F for the systems with outdoor condensing units and 90 °F for the systems with indoor condensing units. For the multiplex systems,  $q_{ss}$  is the measured capacity of the unit coolers at an adjusted suction dew point condition of 19 °F for the cooler and -26 °F for the freezer. Using the above equations, a precise capacity (k Btu/hr) required for the refrigeration system to match with a given WICF envelope could be calculated. However, DOE recognized that an exact match for this calculated capacity may not be available in the refrigeration systems available in the market. Under such a situation, the capacity of the best matched refrigeration system is likely to be the nearest higher capacity refrigeration system available in the market. To account for this phenomenon, DOE multiplied the refrigeration capacity calculated above by a mismatch factor that is greater than one. Multiplying the mismatch factor resulted in somewhat higher capacity systems being coupled to a given WICF envelope.

### 7.3.8 Mismatch Factor

For deriving the mismatch factor, a matching table (Table 7.3.7) is constructed to represent the actual matching process. DOE assumed an unfavorable mismatch situation where a required capacity of 9,000 Btu/ hour was matched to the next available size of the refrigeration system having a capacity of 12,000 Btu/hour (1 ton of refrigeration = 12,000 Btu/ hour) resulting in an oversize factor of 1.33. The oversize factors are computed in 0.5-ton intervals, assuming the industry manufacturer and market refrigeration systems starting with the smallest capacity at 0.5 ton and at 0.5-ton intervals. The oversize factors are plotted against the required capacities, and the resulting plot is presented in Figure 7.3.1.



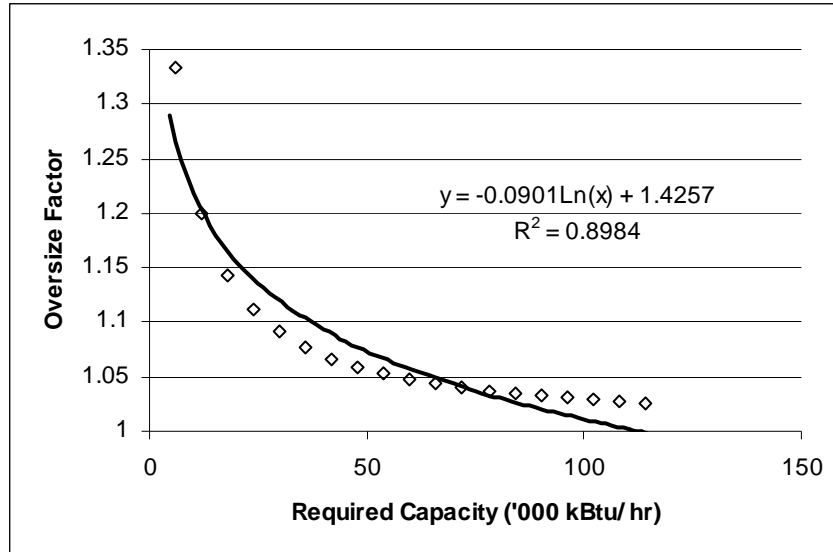
**Table 7.3.7 Capacities and Oversize Factors for the Refrigeration Systems**

<b>Required Capacity (‘000 Btu/hr)</b>	<b>Available Capacity (‘000 Btu/hr)</b>	<b>Oversize Factor</b>
9	6	1.33
15	12	1.20
21	18	1.14
27	24	1.11
33	30	1.09
39	36	1.08
45	42	1.07
51	48	1.06
57	54	1.05
63	60	1.05
69	66	1.04
75	72	1.04
81	78	1.04
87	84	1.03
93	90	1.03
99	96	1.03
105	102	1.03
111	108	1.03
117	114	1.03
	120	

A logarithmic trend line is fitted on the observed points, and a following relationship is obtained.

$$\text{Oversize Factor} = -0.0901 \ln(\text{Required capacity in '000 kBtu/hr}) + 1.4257 \quad \textbf{Eq. 7.8}$$

DOE used the oversize factor described above to calculate the nearest matched capacity of the refrigeration systems.



**Figure 7.3.1 Oversize Factor vs. Required Capacity Plot**

### 7.3.9 Normalized Energy Consumption (NEC) for the Refrigeration System

DOE used the NEC metric for estimating the annual energy consumption of the matched WICF system. The normalized energy consumption has been defined as the annual energy consumption of the refrigeration system divided by its net capacity under specified conditions as defined in AHRI 1250 for determining the key test metric Annual Walk-in Energy Factor (AWEF). The methodology used for computing the NEC metric for the refrigeration systems has been described in detail and the NEC results reported in chapter 5 (Engineering Analysis). This is based on the procedures described in AHRI 1250. The duty cycles, the high load, and the low load factors proposed by DOE essentially follow the AHRI methodology.

In AHRI 1250, the total annual cooling load for the envelope and associated annual energy consumption of the refrigeration system are based on the envelope load model that assumed variation of the cooling load with the outside ambient temperature. This relationship was based on the variability of the conduction heat gain through the three sides of the envelope assumed to be on the exterior perimeter of the building and exposed to the outside ambient condition. This resulted in some small seasonal variation of the cooling load of the envelope. In the DOE model for energy consumption, the variation of the cooling load for the envelope with the outside ambient condition was not modeled explicitly. However, because the Normalized Energy Consumption (NEC) metrics used to estimate the energy consumption were based on the variation of the duty cycle and load factor on outside ambient conditions, the annual energy consumptions derived using NEC results essentially have the same conditions implied.

## 7.4 ENERGY ANALYSIS RESULTS

The annual energy consumptions estimated using the methodology described above for all the envelope product classes analyzed are presented in appendix 7A. A representative table showing annual energy consumption estimates for a medium non-display cooler matched with a dedicated medium-temperature outdoor system is shown in Table 7.4.1.

**Table 7.4.1 Annual Energy Consumption Estimates for a Medium Non-Display Cooler Matched with a Dedicated Medium-Temperature Outdoor System (kWh/ year)**

Type	Non-Display Cooler (Medium)/Dedicated Medium-Temperature Outdoor Systems								
Length × Width × Height (ft)	12' × 20' × 9.5'								
Refrigeration System Efficiency Levels	0	1	2	3	4	5	6	7	8*
Envelope Efficiency Levels									
0	15,547	14,887	13,341	11,173	8,146	5,979	5,200	5,108	4,882
1	9,813	9,398	8,428	7,066	5,165	3,804	3,315	3,257	3,115
2	9,687	9,274	8,309	6,956	5,066	3,713	3,226	3,169	3,028
3	9,654	9,243	8,281	6,932	5,049	3,700	3,215	3,158	3,017
4	8,082	7,738	6,934	5,806	4,231	3,104	2,698	2,651	2,533
5	7,832	7,499	6,719	5,627	4,101	3,009	2,616	2,570	2,456
6	7,529	7,209	6,460	5,410	3,944	2,894	2,516	2,472	2,363
7	7,396	7,082	6,346	5,315	3,875	2,844	2,473	2,429	2,322
8	7,022	6,724	6,026	5,047	3,681	2,702	2,350	2,309	2,207
9	6,753	6,466	5,795	4,855	3,541	2,600	2,261	2,222	2,124
10	6,129	5,869	5,260	4,407	3,216	2,363	2,056	2,020	1,931
11	5,650	5,411	4,850	4,065	2,967	2,181	1,899	1,866	1,784
12	5,406	5,177	4,641	3,889	2,840	2,089	1,818	1,787	1,708
13	5,289	5,065	4,541	3,806	2,779	2,044	1,780	1,749	1,672
14	5,289	5,065	4,541	3,806	2,779	2,044	1,780	1,749	1,672
15*	5,289	5,065	4,541	3,806	2,779	2,044	1,780	1,749	1,672

## 7.5 STATE-BY-STATE ANNUAL ENERGY CONSUMPTION

DOE calculated the average annual energy use for each WICF envelope class matched with outdoor condenser systems for all 237 typical meteorological year (TMY2) stations in the United States. DOE mapped each TMY2 station to a certain State, based on its location. Within each State, DOE assigned a relative weight to each TMY2 station, based on the total population of identifiable population centers (cities, towns, other) that can be shown to be most climatically similar to the TMY2 location. The detailed methodology for developing the weighting factors is discussed in appendix 7B. The annual energy consumption data for the TMY2 locations were then weighted to obtain annual energy consumption data for each State. The State-wise energy consumptions for these systems are given in appendix 7C for the coolers and in appendix 7D for freezers. A representative table showing state-wise annual energy consumption estimates for a medium non-display cooler matched with a dedicated medium-temperature outdoor system is shown in Table 7.5.1.

**Table 7.5.1 State-wise Annual Energy Consumption Estimates for a Baseline Small Non-Display Cooler Envelope matched with Outdoor medium Temperature System (kWh/year)**

<b>Refr. Eff. Level</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>
<b>AK</b>	6,352	6,056	5,017	3,360	3,116	2,815	2,598	1,876	1,849
<b>AL</b>	6,833	6,520	5,404	3,952	3,655	3,311	3,088	2,378	2,346
<b>AR</b>	6,793	6,481	5,372	3,922	3,627	3,283	3,060	2,350	2,318
<b>AZ</b>	6,951	6,634	5,499	4,328	4,001	3,607	3,378	2,671	2,636
<b>CA</b>	6,795	6,484	5,374	3,754	3,472	3,141	2,921	2,213	2,182
<b>CO</b>	6,598	6,294	5,215	3,637	3,367	3,046	2,826	2,111	2,081
<b>CT</b>	6,625	6,320	5,237	3,642	3,372	3,051	2,831	2,117	2,088
<b>DE</b>	6,676	6,369	5,278	3,724	3,446	3,120	2,899	2,186	2,156
<b>FL</b>	6,983	6,665	5,525	4,237	3,916	3,553	3,326	2,618	2,583
<b>GA</b>	6,812	6,500	5,387	3,908	3,614	3,274	3,051	2,342	2,309
<b>HI</b>	7,045	6,725	5,575	4,357	4,026	3,659	3,430	2,723	2,687
<b>IA</b>	6,569	6,266	5,192	3,627	3,359	3,039	2,820	2,103	2,074
<b>ID</b>	6,582	6,278	5,202	3,617	3,349	3,028	2,809	2,093	2,064
<b>IL</b>	6,601	6,297	5,218	3,649	3,379	3,058	2,838	2,122	2,092
<b>IN</b>	6,638	6,332	5,247	3,687	3,413	3,089	2,869	2,155	2,125
<b>KS</b>	6,682	6,375	5,283	3,794	3,511	3,176	2,955	2,241	2,210
<b>KY</b>	6,684	6,377	5,284	3,736	3,457	3,130	2,909	2,196	2,165
<b>LA</b>	6,888	6,574	5,449	4,051	3,745	3,394	3,169	2,461	2,428
<b>MA</b>	6,605	6,301	5,221	3,602	3,334	3,017	2,797	2,083	2,054
<b>MD</b>	6,685	6,378	5,285	3,739	3,460	3,132	2,911	2,198	2,167
<b>ME</b>	6,522	6,220	5,154	3,520	3,260	2,948	2,730	2,013	1,984
<b>MI</b>	6,567	6,263	5,190	3,584	3,319	3,003	2,784	2,068	2,039
<b>MN</b>	6,505	6,204	5,140	3,562	3,299	2,986	2,766	2,048	2,019
<b>MO</b>	6,690	6,382	5,289	3,788	3,505	3,173	2,951	2,238	2,207
<b>MS</b>	6,834	6,521	5,405	3,972	3,673	3,327	3,103	2,393	2,361
<b>MT</b>	6,517	6,215	5,150	3,546	3,285	2,970	2,751	2,034	2,005
<b>NC</b>	6,758	6,448	5,343	3,817	3,531	3,198	2,976	2,265	2,234
<b>ND</b>	6,465	6,166	5,108	3,536	3,276	2,964	2,745	2,025	1,997
<b>NE</b>	6,612	6,307	5,226	3,689	3,415	3,090	2,870	2,154	2,124
<b>NH</b>	6,531	6,229	5,161	3,560	3,298	2,983	2,764	2,047	2,018
<b>NJ</b>	6,670	6,363	5,273	3,707	3,431	3,106	2,885	2,172	2,142
<b>NM</b>	6,707	6,399	5,303	3,775	3,493	3,161	2,939	2,227	2,196
<b>NV</b>	6,787	6,476	5,367	3,991	3,692	3,332	3,108	2,397	2,365
<b>NY</b>	6,647	6,341	5,255	3,670	3,397	3,075	2,855	2,141	2,111
<b>OH</b>	6,608	6,303	5,223	3,630	3,361	3,042	2,822	2,107	2,078
<b>OK</b>	6,764	6,454	5,349	3,898	3,606	3,263	3,040	2,328	2,296
<b>OR</b>	6,649	6,343	5,256	3,597	3,329	3,009	2,791	2,079	2,049
<b>PA</b>	6,633	6,327	5,243	3,662	3,390	3,068	2,848	2,134	2,104
<b>RI</b>	6,612	6,307	5,226	3,615	3,346	3,028	2,808	2,094	2,065
<b>SC</b>	6,802	6,490	5,379	3,892	3,600	3,260	3,038	2,328	2,296
<b>SD</b>	6,530	6,228	5,161	3,605	3,339	3,020	2,800	2,082	2,053
<b>TN</b>	6,770	6,460	5,354	3,874	3,584	3,245	3,022	2,311	2,279
<b>TX</b>	6,883	6,569	5,445	4,080	3,772	3,416	3,191	2,482	2,448

**Table 7.5.1 (contd)**

<b>Refr. Eff. Level</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>
<b>UT</b>	6,642	6,336	5,251	3,713	3,437	3,108	2,887	2,173	2,143
<b>VA</b>	6,708	6,399	5,303	3,760	3,479	3,150	2,929	2,216	2,186
<b>VT</b>	6,519	6,218	5,152	3,545	3,284	2,971	2,752	2,034	2,006
<b>WA</b>	6,616	6,311	5,230	3,545	3,282	2,966	2,748	2,036	2,006
<b>WI</b>	6,524	6,223	5,156	3,557	3,295	2,981	2,762	2,045	2,016
<b>WV</b>	6,661	6,355	5,266	3,680	3,406	3,083	2,863	2,150	2,120
<b>WY</b>	6,516	6,214	5,149	3,533	3,272	2,959	2,741	2,023	1,995